The Lakes of Maple Valley and Covington

A Report on Monitoring Results for the 2009 Water Year at Lake Lucerne, Pipe Lake, and Lake Wilderness

Lake Wilderness, July 2006 *Lake Stewardship Program*

Prepared for the Cities of Maple Valley and Covington
by the King County Lake Stewardship Program

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King County

Overview

The King County Lake Stewardship Program and its predecessor programs have worked with volunteer monitors for more than 17 years on each of the three lakes that are currently completely or partially within the Cities of Maple Valley and Covington. Lakes Lucerne, Pipe, and Wilderness have been monitored since the 1980s. The water quality data indicate that the three lakes are low to moderate in primary productivity with good water quality.

This report refers to two common measures used to predict water quality in lakes: the Trophic State Index or TSI (Carlson 1977), and the nitrogen to phosphorus ratio (N:P). The TSI and N:P ratios were calculated from the data collected through the King County Lake Stewardship (KCLSP) volunteer monitoring program. TSI values are derived from a regression that relates values of a parameter such as total phosphorus, chlorophyll *a* or Secchi transparency to the predicted algal bio-volume, assigning a number on a scale of 0 to 100. This scale can be used to compare water quality over time and between lakes. The TSI values at each of the lakes in Maple Valley have been relatively stable for at least the last 13 years, with no verified trends of declining water quality evident for any of the lakes.

The discussion in this report focuses on the 2009 water year. Specific data used to generate most of the charts in this report can be downloaded from the King County Lake Stewardship data website at:

http://your.kingcounty.gov/dnrp/wlr/water-resources/small-lakes/data/default.aspx

Or it can be provided in the form of excel files upon request.

Lake Lucerne

Volunteer monitoring began at Lake Lucerne in the 1980s and continued through 2009, with a gap in the early 1990s. The data indicate that this 16-acre lake is relatively low in primary productivity (oligotrophic - mesotrophic) with good to excellent water quality.

Lake Lucerne has no public access boat launch, but does have a history of both milfoil and hydrilla infestations for which eradication efforts have been underway since 1995. Milfoil has been eradicated, and the last hydrilla plant was found five years ago. Lake Lucerne is no longer treated with herbicide but maintains very low levels of fluridone (Sonar PR ™) because the channel connecting Pipe to Lucerne allows for water exchange. After 2009, Pipe Lake will no longer be treated, and aquatic plants should begin to recover in the shallow water zones of the lake. Lake users and residents should keep a close eye on aquatic plants growing nearshore to catch new or expanding patches of noxious weeds.

Physical Parameters

No precipitation or lake level data were collected for Lake Lucerne in 2009.

Secchi transparency is a common method used to assess and compare water clarity. It is a measure of the water depth at which a black and white disk disappears from view when lowered from the water surface.

Volunteers collected Secchi transparency and temperature data from early May through late October during the "Level 2" monitoring season when volunteers collect water samples for laboratory analysis. Secchi transparency ranged between 2.5 and 6.2 m from May through October, averaging 4.9 m, which was in the upper third of the small lakes monitored in 2009 (Figure 1).

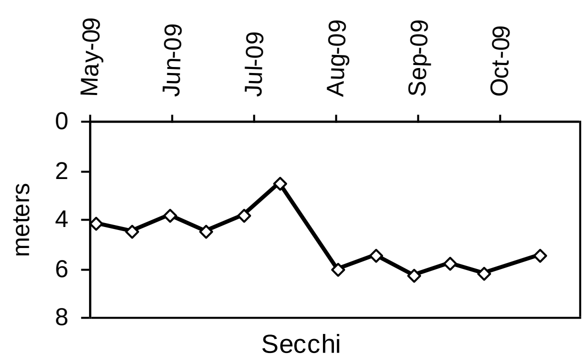

Figure 1. WY 2009 Lake Lucerne Secchi Depth

Surface water temperatures reached ranged from 14.0 to 27.5 degrees Celsius, with an average of 21.3 degrees Celsius, making average lake temperature warmer than in 2008 (Figure 2).

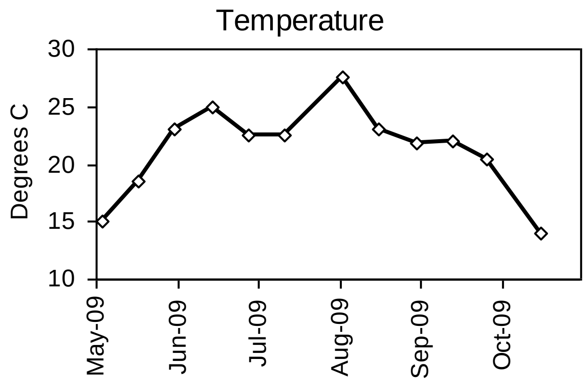

Figure 2. WY 2009 Lake Lucerne Temperature

Nutrient and Chlorophyll Analysis (Lake Lucerne)

Phosphorus and nitrogen are naturally occurring elements necessary in small amounts for both plants and animals. However, many actions associated with residential development can increase concentrations of these nutrients beyond natural levels. In lakes of the Puget Sound lowlands, phosphorus is often the nutrient in least supply, meaning that biological productivity is often limited by the amount of available phosphorus. Increases in phosphorus concentrations can lead to more frequent and dense algae blooms – a nuisance to residents and lake users, and a potential safety threat if blooms become dominated by species that can produce toxins. Samples collected by volunteers are analyzed for total phosphorus (TP) and total nitrogen (TN) concentrations at one meter depth.

Total phosphorus (TP) and total nitrogen (TN) varied slightly through the sampling period. TN concentrations began higher in spring and tapered off until fall with little variation. Phosphorus was generally stable at low levels throughout the season (Figure 3).

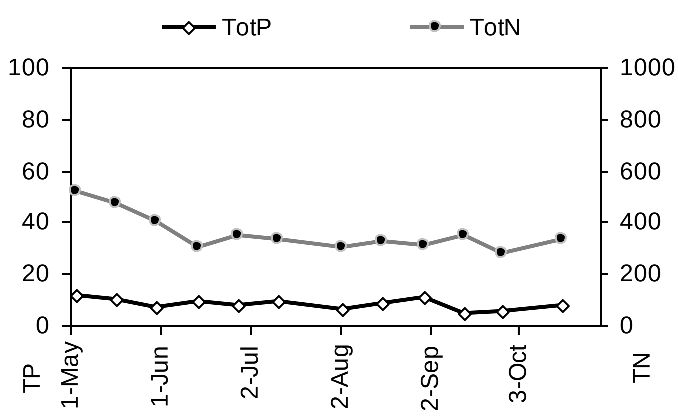

Figure 3. WY 2009 Lake Lucerne Total Phosphorus and Total Nitrogen Concentrations

The ratio of nitrogen (N) to phosphorus (P) can be used to determine if conditions are favorable for the growth of cyanobacteria (bluegreen algae) that can impact beneficial uses of the lake. When N:P ratios are near 20 or below, cyanobacteria often dominate the algal community due to their ability to take nitrogen from the air. Total phosphorus and total nitrogen remained in relatively constant proportion to each other through the sampling period, ranging from 29.4 to 69.0 with an average of 44.9, which suggests generally poor conditions for the growth of nuisance bluegreen algae at Lake Lucerne.

Chlorophyll *a* concentrations remained relatively stable throughout the season, except for one significant drop spring. The majority of the pheophytin, which is degraded chlorophyll, levels were below detection levels throughout the period (Figure 4).

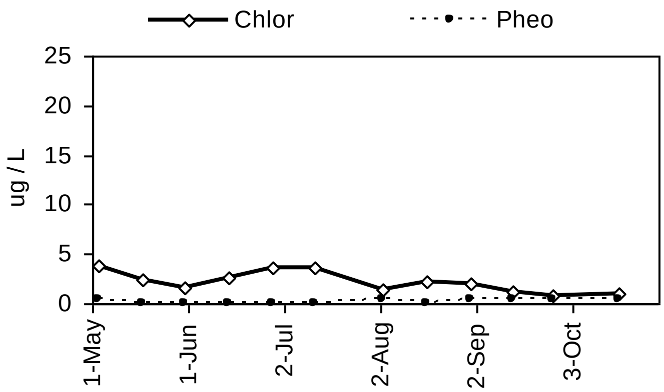

Figure 4. WY 2009 Lake Lucerne Chlorophyll *a* and Pheophytin concentrations

Profile data indicate that thermal stratification was present by mid-May and persisted through the summer (Table 1).

Table 1. Lake Lucerne Profile Sample Analysis Results. Sample values below minimum detection level are marked <MDL.

Lake name	Date	Secchi	Depth	DegC	Chlor-a	Pheo	Total N	NO2-3	NH3	Total P	OPO4	UV254	Total Alk
Lucerne	5/17/09	4.5	1	18.5	2.43	**<MDL**	0.4760	0.1330	0.0184	0.0100	**<MDL**	0.0962	33.8
Lucerne			5	20.5	3.43	**<MDL**	0.296			0.0085			
Lucerne			9	9			1.070	**<MDL**	**<MDL**	0.0875	0.002		
Lucerne	8/31/09	6.3	1	21.8	2.11	**<MDL**	0.309	**<MDL**	**<MDL**	0.0105	**<MDL**	0.0756	36.5
Lucerne			5	9.5	4.82	**<MDL**	0.5360			0.0079			
Lucerne			9	6.5			0.4890	0.1640	0.0782	0.0120	**<MDL**		

Concentrations of total phosphorus (Total P) in the deep water remained relatively low, and the deep water concentration decreased by the end of August. The amount of orthophosphate (OPO4) also was low on both dates, showing no signs of major release of phosphorus from the sediments. This suggests the higher total phosphorus in May was probably due to particulate organic material.

Chlorophyll *a* data (Chlor) indicate that algae were more or less equally distributed through the shallow depths of the water column at fairly low concentrations, with little degraded chlorophyll present (pheophytin).

The forms of dissolved inorganic nitrogen present at 1m in May (NO2-3 and NH3)were essentially gone by the end of summer, although some remained in the deep water. Alkalinity, also known as acid neutralizing capacity or buffering capacity, was relatively low, while water color (UV254) was very low, indicating that dissolved organic carbon was not important in the lake.

TSI Ratings (Lake Lucerne)

The 2009 TSI values for chlorophyll were up in the upper range of oligotrophy and TSI-TP was in the mid range of oligotrophy, and the TSI value for Secchi was slightly higher, just above the threshold of mesotrophy (Figure 5). The average of the three values was 37.4, putting Lake Lucerne in the upper range of oligotrophy, indicating it is between low and intermediate primary productivity. The relationships between the 3 different indicators have held remarkably steady for the past 4 years.

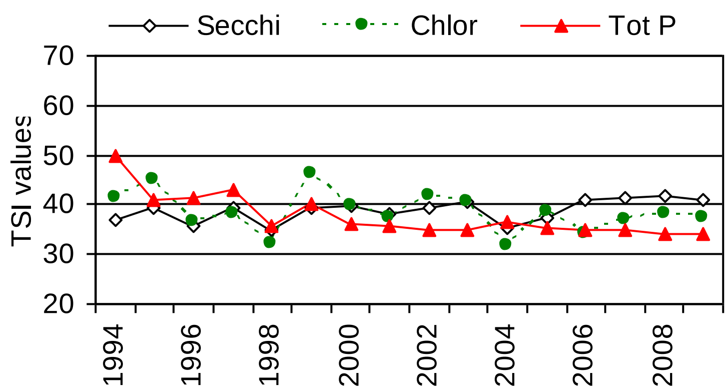

Figure 5. Lake Lucerne Trophic State Indicators

Side-by-side measurements

In 2003, a Hearing Examiner took testimony concerning a SEPA appeal on the permit for development of a piece of land within the City of Maple Valley known as the "Brown Plat." The appeal was based in part on the potential for adverse effects from the development on water quality in Lake Lucerne. The document entitled Findings, Conclusions and Decision on the Shoreline Substantial Development Permit (Case no. PP01-1482/CD0207-001) included instructions to the City of Maple Valley to fund professionally-collected water quality sampling of Lake Lucerne in tandem with the long-term volunteer-assisted lake monitoring by the King County Lake Stewardship Program.

In 2009, the first side-by-side measurements of lake water quality were made by both King County professional staff and the Lake Lucerne water quality monitor. These included water sample collection, Secchi transparency and temperature readings taken within a short time timespan. All water samples were delivered to the King County Environmental Laboratory for analysis and were run in the same batch, thus limiting analytical error as an explanation for differences. Samples were collected at 1 m for comparison on four different dates: July 12, August 3, August 17, and August 31, 2009.

The results suggest very good consistency between professionally collected and volunteer collected data for Lake Lucerne at this time (Table 2), bolstering the reliability of the volunteer collected data up to this point. All of these data are well within the bounds of replicability, with an average difference of 10% or less, even for the Secchi transparency reading which depends on light levels, windiness, glare off the water surface, and the keenness of vision of the field crew.

Table 2. Lake Lucerne Profile Sample Analysis Results

Parameter	Volunteer	King County	%diff
Secchi transparency (m)	5.1	5.6	9%
Temperature (deg Celsius)	23.7	23.0	-3%
Total Nitrogen (mg/L)	0.319	0.334	5%
Total Phosphorus (mg/L)	0.0087	0.0096	10%
N : P ratio	37.9	35.5	-7%
Trophic State - TP	35.1	36.6	4%

Analytical tools, such as the N:P ratio and the trophic state indicators, produce small differences on the same scale, which indicates that the conclusions drawn from both sets of data would have been the same.

This side-by-side sampling will be carried out again in the summer of 2010.

Conclusions and Recommendations

Based on monitoring data, water quality in Lake Lucerne appears to have been stable over the period measured. High N:P ratios indicate conditions are not favorable for nuisance bluegreen algae blooms. Watershed development is occurring in the Lake Lucerne basin, and the lake should continue to be monitored to insure that conditions from increased development do not affect the water quality of the lake. With the sunset of herbicide treatments as part of the hydrilla eradication project in both Pipe and Lucerne Lakes, the city and the residents around the lake should be vigilant in looking for invasive aquatic plants colonizing the lake, such as Eurasian watermilfoil, in addition to the return of native aquatic plants.

Pipe Lake

Volunteer monitoring began at Pipe Lake in the 1980s and has been continuous since 1993. The data indicate this 52-acre lake is low to moderate in primary productivity (oligotrophic - mesotrophic) with very good water quality. Nearly 50% of the shoreline of Pipe Lake is in the City of Maple Valley. The remainder is in the City of Covington.

Pipe Lake has no public access boat launch, but there is a community boat launch at Cherokee Bay. Pipe Lake, which is connected to Lake Lucerne by a short channel, also has a history of both milfoil and hydrilla infestations for which eradication efforts have been funded by government agencies since 1995. Eurasian watermilfoil has been eradicated, and the last plant of hydrilla was found in 2006. The 2009 season should be the last one in which herbicide is applied to the lake, and in 2010 the plan is to focus on surveying the lake for any resurgence of hydrilla and documenting the return of native aquatic plants to the lake. Residents should watch aquatic plants growing nearshore to catch growing patches of milfoil, Hydrilla or other noxious weeds.

Physical Parameters

No precipitation or lake level data were collected for Pipe Lake in 2009.

Volunteers collected Secchi transparency and temperature data from early May through late October during the "Level 2" monitoring season when volunteers collect water samples for laboratory analysis. Secchi transparency from late May through October ranged from 4.6 to 8.0 m, averaging 6.3 m which is among the higher transparencies on record for a season among the small lakes of King County (Figure 1).

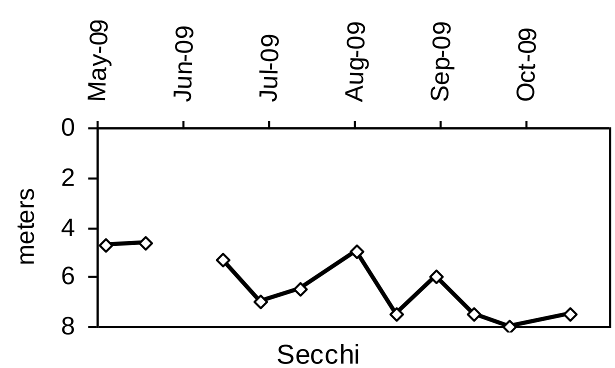

Figure 1. WY 2009 Pipe Lake Secchi Depth

Water temperatures for the same period ranged from 13.0 degrees Celsius to a peak of 27.0 degrees Celsius with an average of 20.2, which was warmer than the previous year and in the upper range for maximum temperatures recorded among the monitored lakes (Figure 2).

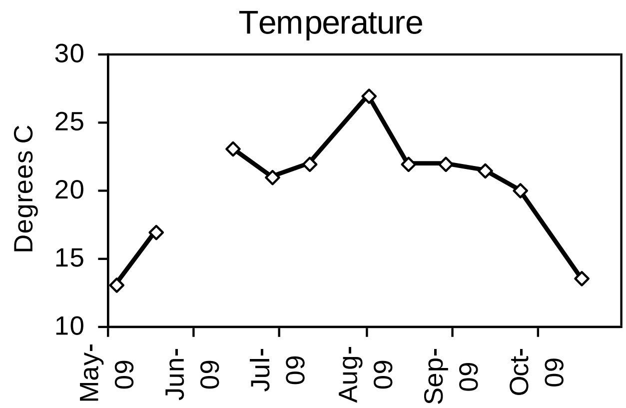

Figure 2. WY 2009 Pipe Lake Temperature

Nutrient and Chlorophyll Analysis (Pipe Lake)

Phosphorus and nitrogen are naturally occurring elements necessary in small amounts for both plants and animals. However, many actions associated with residential development can increase concentrations of these nutrients beyond natural levels. In lakes of the Puget Sound lowlands, phosphorus is often the nutrient in least supply, meaning that biological productivity is often limited by the amount of available phosphorus. Increases in phosphorus concentrations can lead to more frequent and dense algae blooms – a nuisance to residents and lake users, and a potential safety threat if blooms become dominated by species that can produce toxins. Samples collected by volunteers are analyzed for total phosphorus (TP) and total nitrogen (TN) concentrations at one meter depth.

Total phosphorus and total nitrogen had only slight variation through the sampling period. Nitrogen declined from early May remaining stable from the beginning of August through the rest of the season (Figure 3). Phosphorus varied a little from date to date, but remained essentially the same through the same period. The N:P ratio ranged from 27 to 84, averaging 46, which is very similar to 2008 and indicated generally poor conditions for nuisance bluegreen growth.

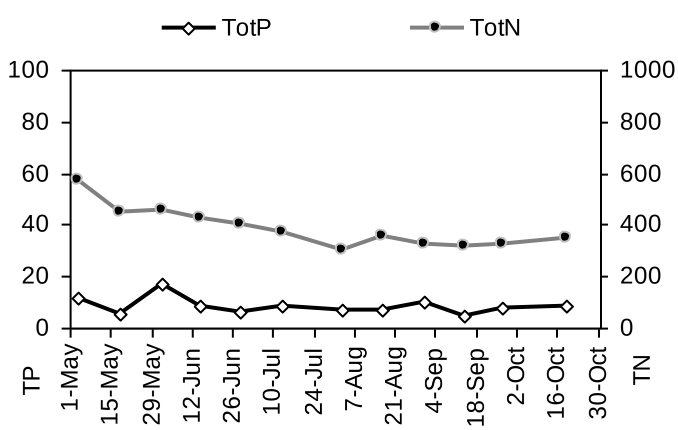

Figure 3. 2009 Pipe Lake Total Phosphorus and Total Nitrogen Concentrations

Chlorophyll was stable at low levels through the sampling season after an initially high value that equated with a spring bloom. This indicates low phytoplankton concentrations in Pipe Lake throughout the summer.

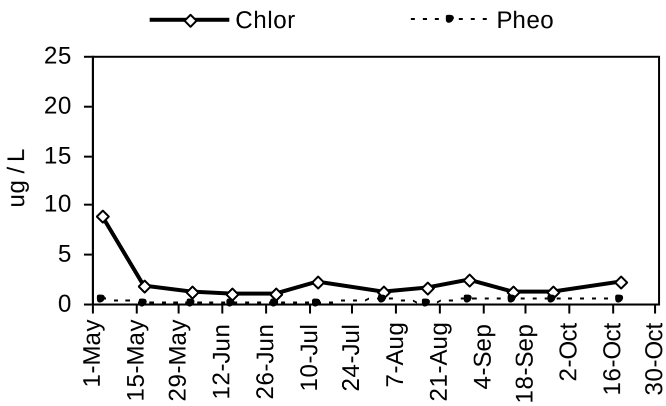

Figure 4. WY 2009 Pipe Lake Chlorophyll *a* and Pheophytin concentrations

Profile data indicate that thermal stratification was present early in the season and persisted through the summer. The deep water temperature remained cool throughout stratification. There was a significant build up of total and dissolved phosphorus (Total P and OPO4), as well as ammonia (NH3), in the deep water in the August profile, suggesting low oxygen conditions that may have resulted in a phosphorus release from the sediments. Chlorophyll *a* data indicated that algae were more abundant at the middle depth in May, but approximately equivalennt in August.

Table 1. Pipe Lake Profile Sample Analysis Results. Sample values below minimum detection level are marked <MDL.

Lake name	Date	Secchi	Depth	DegC	Chlor-a	Pheo	Total N	NO2-3	NH3	Total P	OPO4	UV254	Total Alk
Pipe	5/18/09	4.6	1	17.0	1.72	**<MDL**	0.446	0.138	0.017	0.0053	**<MDL**	0.0919	33.7
Pipe			10	8.0	6.86	**<MDL**	0.586			0.0072			
Pipe			19	6.5			0.586	0.338	**<MDL**	0.0095	**<MDL**		
Pipe	8/31/09	6.0	1	22	2.47	**<MDL**	0.325	0.010	0.009	0.0099	**<MDL**	0.0947	36.4
Pipe			10	8.5	3.33	**<MDL**	0.569			0.0087			
Pipe			19	6			1.390	**<MDL**	1.39	0.3040	0.0893		

Alkalinity, also known as acid neutralizing capacity or buffering capacity, was relatively low and almost equivalent to Lake Lucerne, while water color (UV254) also was very low, contributing to water clarity and indicating that dissolved organic carbon was not important in the lake.

TSI Ratings (Pipe Lake)

A common method of tracking water quality trends in lakes is by calculating the "trophic state index" (TSI), developed by Robert Carlson in 1977. TSI indicators predict the biological productivity of the lake based on water clarity (Secchi) and concentrations of TP and chlorophyll *a* (see discussion under Lake Lucerne). The 2009 TSI indicators for chlorophyll *a* and TP were close to each other in the mid range of oligotrophy. The TSI – Secchi indicator was in upper end of the oligotrophic range (Figure 5). Pipe Lake is solidly in the range for oligotrophy and it appears to have been stable for the last few years.

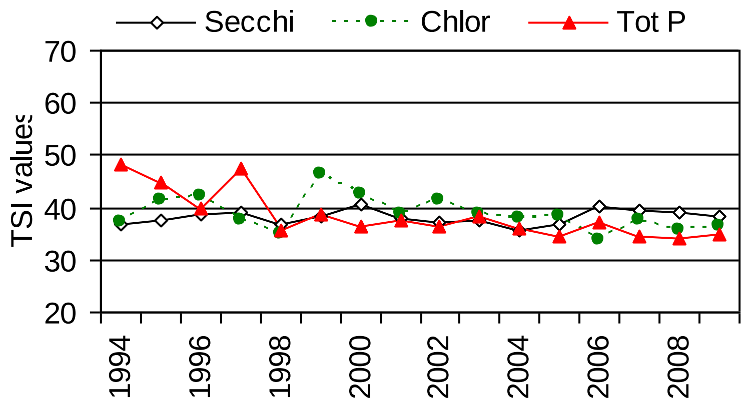

Figure 5. Pipe Lake Trophic State Indicators

Conclusions and Recommendations

Based on monitoring data, water quality in Pipe Lake appears to have been stable over at least the last 7 years and perhaps longer, although the values were more variable in earlier years of the monitoring. High N:P ratios indicate conditions in the lake are not favorable for nuisance bluegreen algae blooms. With the sunset of the hydrilla eradication project, the city and the residents around the lake should be vigilant in looking for invasive aquatic plants, such as Eurasian watermilfoil and Hydrilla, as the aquatic vegetation returns to the lake.

Lake Wilderness

Volunteer monitoring began at Lake Wilderness in the early 1980s and has continued through 2009. The data indicate this 67-acre lake is moderate in primary productivity (mesotrophic) with generally good water quality.

Lake Wilderness has a public access boat launch. There is a history of Eurasian watermilfoil infestation with control activities funded and monitored by the community and the city of Maple Valley. Residents have been active stewards of the lake through the years and should continue to watch for new patches of Eurasian milfoil, as well as other noxious weeds that might invade the lake, such as Brazilian elodea.

Physical Parameters

Excellent records of precipitation and water level were kept over the year (Figure 1). The lake level followed the regional pattern of winter high - summer low stands, with some sensitivity recorded to large rain events, particularly in late fall - winter. There was a difference of 68 cm between the highest and lowest stands during the year, which is similar to 2008 but much less than the difference recorded for many previous years.

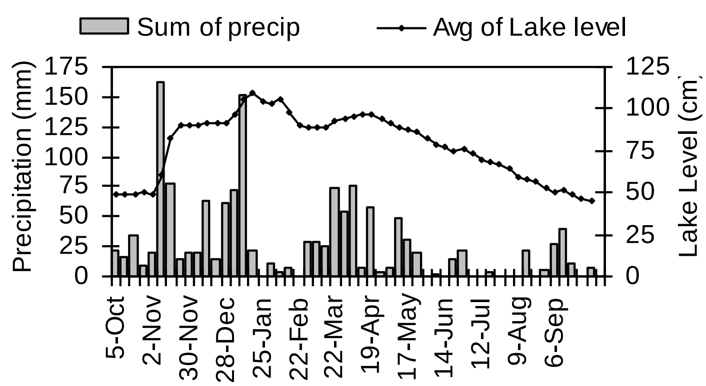

Figure 1. WY 2009 Lake Wilderness Level and Precipitation

Secchi transparency ranged from 2.5 to 8.3 m through the year (Figure 2). The summer average of 6.7 m placed it among the clearest of the small lakes monitored in 2009.

However, water clarity dropped in October, concurrent with the persistence of a toxic bluegreen bloom that accumulated along downwind shorelines, causing the City to close the swimming beach as a safety precaution and keep cautionary signage posted at the lake well into autumn. While most of the lake water was clear, the algae scum moved around the lake rapidly with the wind direction, making it impossible to predict where people could safely swim or take their pets to play in or by the water on any particular day.

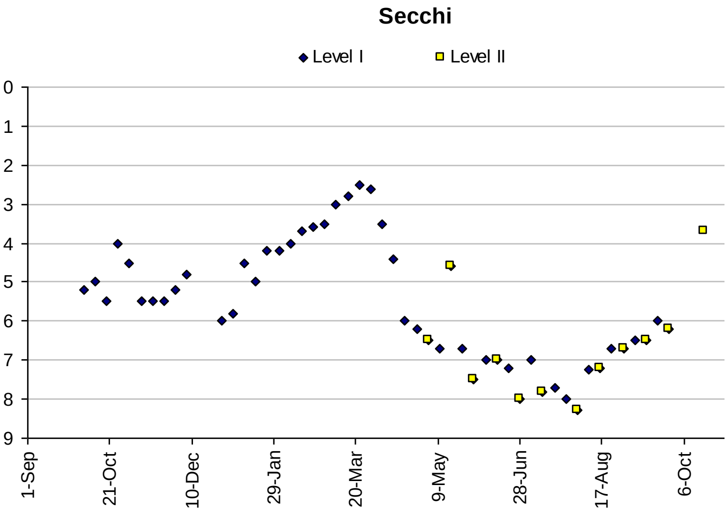

Figure 2. WY 2009 Lake Wilderness Secchi

Annual water temperatures ranged from 3.2 to 26.5 degrees Celsius (Figure 3), with a summer average of 19.6 degrees Celsius, placing Lake Wilderness among the cooler group of the 13 lakes monitored in 2009.

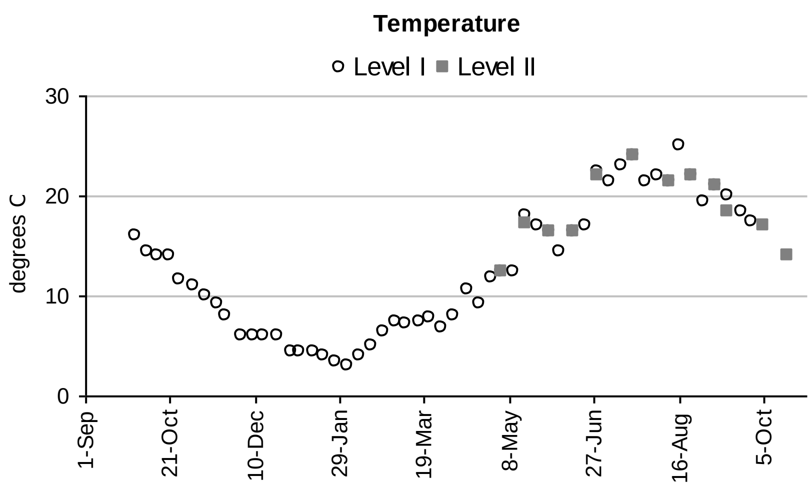

Figure 3. WY 2009 Lake Wilderness Temperature

Nutrients and Chlorophyll (Lake Wilderness)

Phosphorus and nitrogen are naturally occurring elements necessary in small amounts for both plants and animals. However, many actions associated with residential development can increase concentrations of these nutrients beyond natural levels. In lakes of the Puget Sound lowlands, phosphorus is often the nutrient in least supply, meaning that biological productivity is often limited by the amount of available phosphorus. Increases in phosphorus concentrations can lead to more frequent and dense algae blooms – a nuisance to residents and lake users, and a potential safety threat if blooms become dominated by species that can produce toxins. Samples collected by volunteers are analyzed for total phosphorus (TP) and total nitrogen (TN) concentrations at one meter depth.

Total nitrogen decreased from May through August, after which it remained steady, even slightly increasing through the end of the sampling period. Total phosphorus remained steady through July and then increased slowly (Figure 4). The N:P ratio ranged from 15 to 75, averaging 39 over the whole season, which suggested that during some of the time conditions were poor for nuisance bluegreen growth. However, after August the N:P values were below 20, indicating that favorable conditions existed for bluegreen algae growth, consistent with the development of a bluegreen bloom that persisted through fall. Cyanobacteria in the lake will be discussed in a later section.

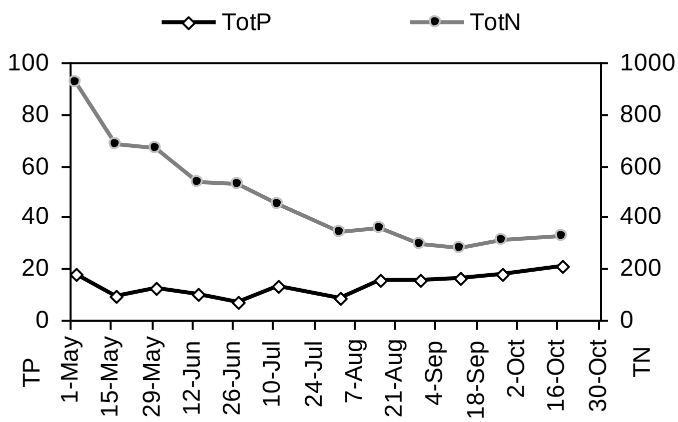

Figure 4. 2009 Lake Wilderness Total Phosphorus and Total Nitrogen Concentrations

Chlorophyll *a* varied through the sampling period at Lake Wilderness, with slightly higher concentrations in mid May and August, then climbing steadily from mid September through the end of the sampling period in October.

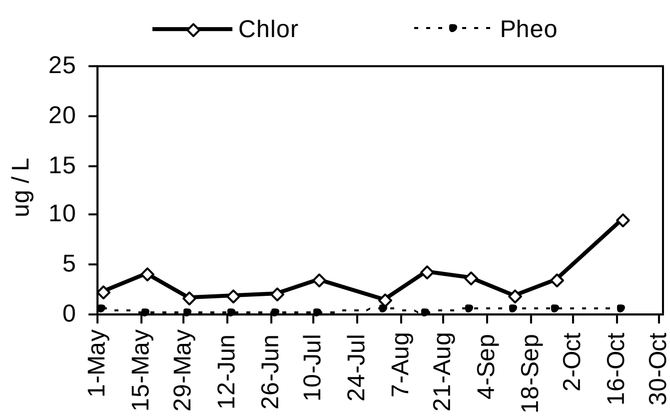

Figure 5. WY 2009 Lake Wilderness Chlorophyll *a* and Pheophytin concentrations

Profile data indicate that thermal stratification was present early in the season and persisted through the summer, though the deep water showed a significant temperature increase by the end of August. In the May profile event, phosphorus and ammonia were building in the deep water sample, consistent with low oxygen and nutrient recycling from the sediment. The lower values in the deep water in August, coupled with the warmer temperature, suggest that some water turnover had already occurred, thus making deep water nutrients available to the phytoplankton. While chlorophyll was evenly distributed through the water column in May, it was concentrated in the deeper water in August, and this may be related to the mixing of the water column as well.

Table 1. Lake Wilderness Profile Sample Analysis Results. Sample values below minimum detection level are marked <MDL.

Lake name	Date	Secchi	Depth	DegC	Chlor-a	Pheo	Total N	NO2-3	NH3	Total P	OPO4	UV254	Total Alk
Wilderness	5/17/09	4.6	1	15.5	4.10	**<MDL**	0.685	0.470	**<MDL**	0.0092	**<MDL**	0.0411	47.8
Wilderness			4	13.2	4.92	**<MDL**	0.708			0.0147			
Wilderness			8	8.2	3.55	12.20	0.483	0.143	0.126	0.0498	0.0071		
Wilderness	8/30/09	6.7	1	21.5	3.58	**<MDL**	0.297	**<MDL**	0.015	0.0155	**<MDL**	0.0367	50.7
Wilderness			4	21.5	3.75	**<MDL**	0.280			0.0162			
Wilderness			7.5	18	15.20	5.73	0.385	**<MDL**	0.027	0.0580	0.0037		

Alkalinity, also known as acid neutralizing capacity, was higher than in Pipe and Lucerne, suggesting that soils and source rocks in the watershed contain more dissolved salts that contribute to buffering capacity. Water color (UV254) was lower than Pipe and Lucerne, contributing to the exceptional water clarity and indicating that dissolved organic carbon was not abundant in the lake.

TSI Ratings (Lake Wilderness)

In 2009, the average TSI-Secchi was on the threshold between oligotrophy and mesotrophy (Figure 6). The values for TSI-chlorophyll and TSI-phosphorus were in the mesotrophic range and the TSI value for Secchi transparency was in the low range of oligotrophy. This disparity among TSI values has been persistent over the years of monitoring, with water clarity being a predictor of lower algal biovolumes than what is predicted from the chlorophyll and phosphorus indicators.

Lake Wilderness is exceptionally clear, and it may be that the type of algae that can do well in the lake are those that produce colonies that make particles in the water instead of single cells that produce cloudiness when abundant. This could make the lake more susceptible to scum formations on the downwind shorelines than a lake which produced algae that cloud the water, but are not easily moved by wind and waves.

The average of the TSI values put Lake Wilderness in the lower end of mesotrophy, likely even a little lower in algal production than in previous years. However, because this is the first year that bluegreen toxicity has been measured routinely, the rate at which algae in the lake become toxic is not known, which is a different question than how abundant the algae are..

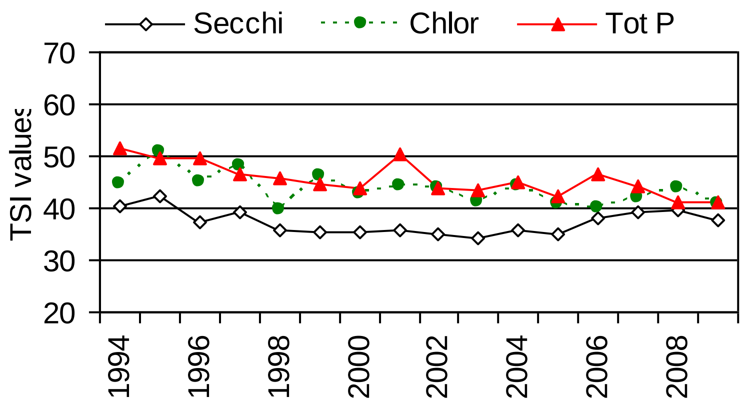

Figure 6. Lake Wilderness Trophic State Indicators

Cyanobacteria toxins

Because of its history of occasionally producing bluegreen (cyanobacteria) blooms, Lake Wilderness was chosen as one of 30 Puget lowland lakes to be studied as part of work funded by a grant from the Center for Disease Control (CDC) to the Washington Department of Health, working with the collaboration of King, Snohomish, and Pierce Counties. The study involves regular biweekly sampling at a selected site for bluegreen species abundance and toxicity between June and October for three consecutive years. Blooms will be sampled as well when identified elsewhere in the lake other than the routine sample site. Four algal toxins are to be measured: microcystin, anatoxin, saxitoxin and cylindrospermopsin.

In Lake Wilderness, the routine site chosen was at the swimming beach because that is the point at which the most people come in contact with the water. For most of the 2009 season, toxin measurements were below analytical detection limits. However, beginning in mid-August traces of microcystin were found in the water just off the public swimming beach, and at that site remained below the state recreational standard of 6 ug/L until October 18th. However, on August 23rd a sample from an algal scum found north of the beach near the Lake Wilderness Lodge measured 15.4 ug/L, thus leading to a decision by the City to post warning signs at the beach and boat launch. Values dropped after this and were relatively low until early October, when a scum sample measured 154, although the beach sample was 0.17 ug/L. Maximum values were reached in mid to late October, when both scum and routine samples were well above the recreational limit, and it was not until the end of November when the cyanobacteria were breaking down, that toxin values declined to below the state guideline.

Conclusions and Recommendations

Based on monitoring data, water quality in Lake Wilderness appears to be stable over the period measured. Low N:P ratios in the fall indicate conditions are probably favorable for nuisance bluegreen algae blooms, and the lake water clarity suggests that those blooms are taking the form of large colonies that make particles in the water, thus favoring scum accumulations along downwind shorelines. Close monitoring of algae blooms at the lake in the fall should continue, including participation in the CDC grant project and the Washington State Department of Ecology's Toxic Algae Monitoring program to determine whether or not blooms at the lake produce toxins.

There is a statistically weak trend suggesting total phosphorus is decreasing, and concentrations should continue to be monitored to determine if this is a strong long-term trend. Over time, it may contribute to an increase in the N:P ratio, which could make the lake less hospitable to bluegreen blooms.